Hydrological Forecasting

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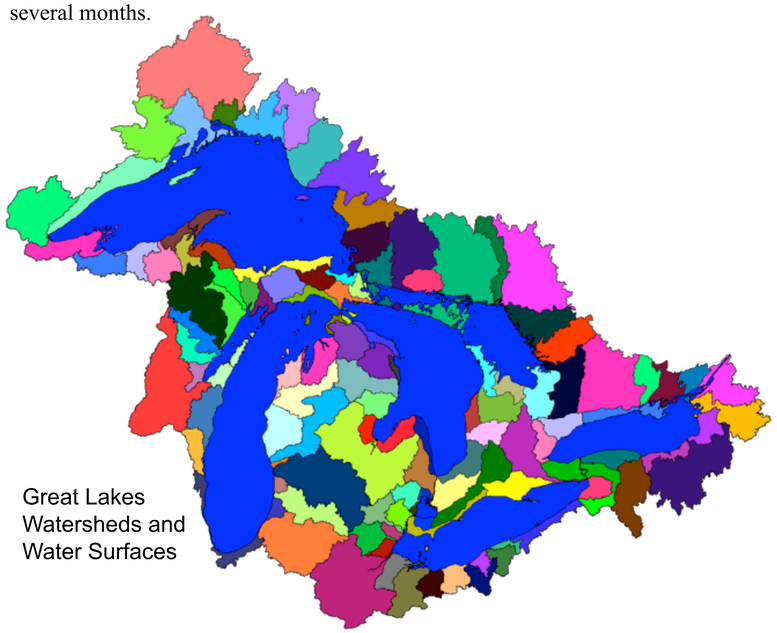
GOAL

Daily forecast monthly contributing watershed storages and flows and Great Lakes storages and flows, including lake levels, along with their probabilities over the next several months.

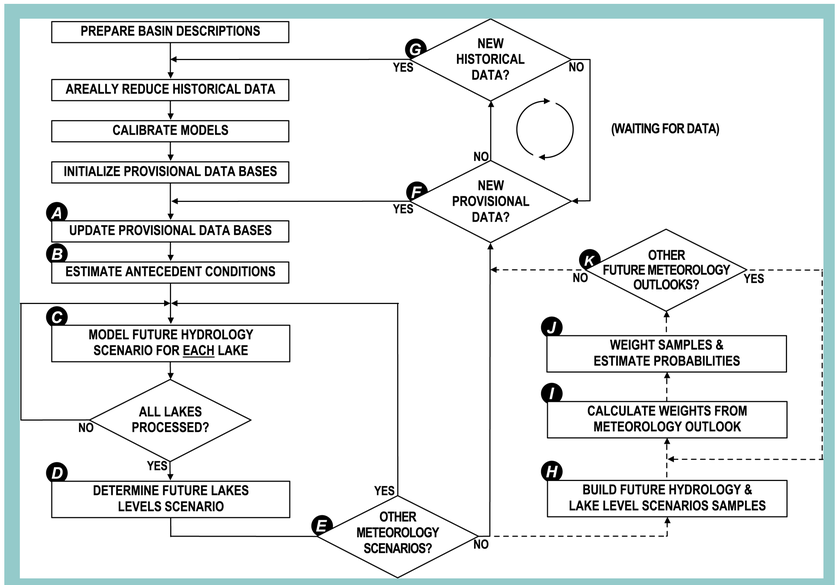


The Great Lakes Environmental Research Laboratory's (GLERL's) Advanced Hydrologic Prediction System (AHPS) uses climate predictions from the NWS, Environment Canada, and others. It provides multiple-month probability outlooks for 25 hydrology variables over the 121 watersheds and 7 lake surfaces of the Great Lakes basin, including simultaneous water levels on all lakes. The system incorporates both current conditions, antecedent to a forecast, and multi-agency, multi-area, multi-period climate outlooks of meteorology probabilities. GLERL's AHPS use of antecedent conditions adds considerably to Great Lakes forecasting ability when compared to other Great Lakes forecasting methodologies, while the use of existing meteorological outlooks currently adds little. GLERL's AHPS offers the advantage of improvement as better near real-time data streams and improved process models become available.

Science Behind Forecasts

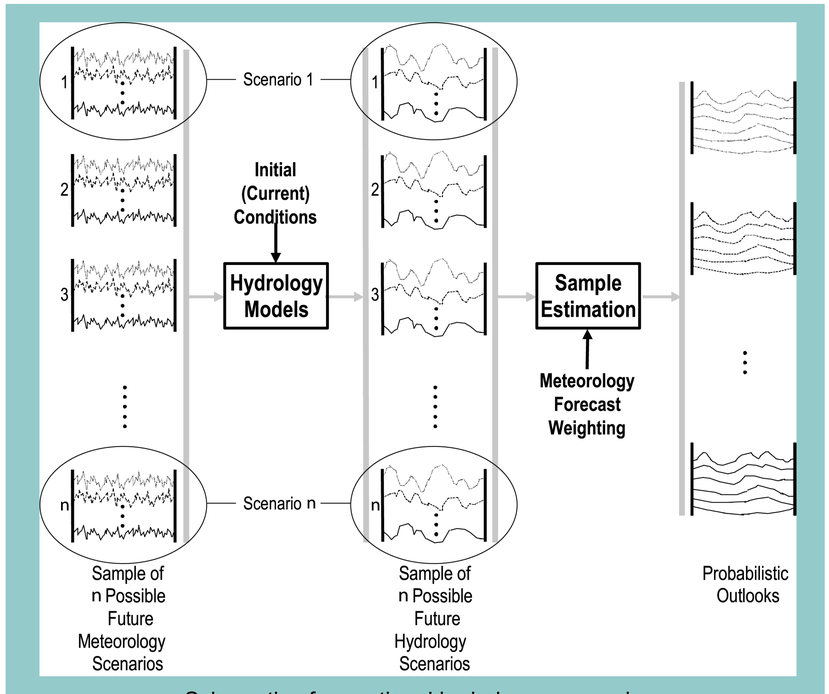
GLERL developed, calibrated, and verified conceptual model-based techniques for simulating hydrological processes in the Laurentian Great Lakes (including Georgian Bay and Lake St. Clair, both as separate entities). GLERL integrated the models into a system to estimate lake levels, whole-lake heat storage, and water and energy balances. These include models for rainfall-runoff, evapotranspiration, and basin moisture storage (121 daily watershed models), overlake precipitation (a daily estimation model), one-dimensional (depth) lake thermodynamics (7 daily models for lake surface flux, thermal structure, evaporation, and heat storage), net lake supplies, channel routing (daily models for connecting channel flows and levels, outlet works, and lake levels), lake regulation (a monthly plan balancing Lakes Superior, Michigan, and Huron), and diversions and consumption. The modeling system is modularly built, allowing model upgrades to be "dropped in" as developed and tested.

Deterministic Hydrology Forecasts. GLERL first developed a deterministic forecast as a semiautomatic software package. It integrates modeling and near real-time data handling and reduction to enable representation of current system states and simulated futures. The overview in the next column (excluding dashed-line portion) shows deterministic forecasts. Inputs are daily air temperature, dew point temperature, precipitation, wind speed, and cloud cover for all available stations. Optional inputs are snow water equivalent, soil moisture, lake water temperature, and lake levels.



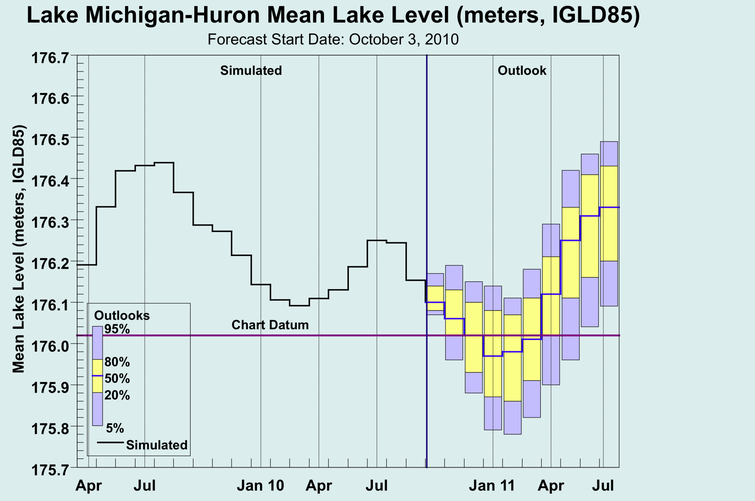
Overview of Great Lakes Advanced Hydrologic Prediction System

GLERL converts daily provisional point data into areal averages for each watershed and lake surface by Thiessen weighting over digital maps of the areas (A). GLERL's runoff model (applied to each Great Lakes watershed) and their lake thermodynamics model (applied to each lake) use the areal averages to estimate basin moisture and lake heat as antecedent (initial) conditions to a forecast (B). A deterministic "forecast" of all hydrology variables, including lake supply, may then be made by simulating the hydrology from the point of estimated initial conditions forward with a meteorology scenario (taken from the historical record, for example) (C). The resulting lake supply scenarios, one for each lake, are then used with connecting-channel routing and lake regulation models to determine a lake levels scenario (D). This can be repeated for alternate meteorology scenarios (E). New provisional data are used as they become available (F); new historical data are also used as available to update models and databases (G).



Schematic of operational hydrology approach

Probabilistic Hydrology Forecasts. GLERL adapted this deterministic forecasting methodology to make probabilistic forecasts by considering historical meteorology as possibilities for the future. An *operational hydrology* approach segments the historical record and uses each segment with models to simulate a possible "scenario" for the future; see schematic preceding. Sections of the historical meteorology record are input to hydrological, limnological, and other models (E) as alternate meteorology scenarios, preserving observed spatial and temporal interrelationships. Corresponding hydrology variable scenarios are computed for the future, including lake supply scenarios (H). Each scenario may be weighted to agree with probabilistic meteorology outlooks (available from NOAA's Climate Prediction Center, Environment Canada's Atmospheric Service, and others) (I, J). The resulting set of weighted scenarios serves as a statistical sample for inferring probabilities and other parameters associated with both meteorology and hydrology (see schematic in next column). Probabilistic hydrology outlooks then are made from the sample for each variable of interest. Thus, the resulting probabilistic hydrology outlooks properly consider antecedent hydrological conditions and predictions of meteorology. An example follows:



Example Probabilistic Hydrological Forecast

Users

Users include lake navigation interests such as Great Lake Carriers who use water level forecasts to plan carrying capacity in ships based on available draft in connecting channels. Marina operators and other riparian businesses use AHPS to plan dredging needs during times of low water levels, or facility modifications during times of high water levels. Regulation of Superior/Michigan-Huron water levels and of Ontario/St. Lawrence water levels use hydrological forecasts; the US Army Corps of Engineers (Detroit district) and the Great Lakes—St. Lawrence Regulation Office of Environment Canada, use GLERL's AHPS as companion to their traditional techniques in an evaluation mode, to make and issue their monthly forecasts of extended Great Lakes hydrology and lake levels. The International Joint Commission used GLERL's AHPS in its 5-yr study of Lake Ontario—St. Lawrence River regulation. Municipal water utilities also make use of the forecasts in the management of their water intakes. Hydropower utilities (New York Power Authority, Ontario Power Generation, and Hydro Quebec) use the forecasts in both supply and demand determinations.

Status

GLERL's AHPS is fully operational. It is being used each day to produce a 9- or 10-month outlook, and those results are then made available online at the address below. GLERL may continue to develop hydrological/meteorological weighting refinements over the next few years. http://www.glerl.noaa.gov/wr/ahps/curfcst/curfcst.html